Ontario Department of Agriculture

HORTICULTURAL EXPERIMENTAL STATION
VINELAND STATION, ONT.

TORONTO, ONT. SPECIAL BULLETIN MARCH, 1928

IMPERIAL BUREAU OF MYCOLOGY

DEAD ARM OF GRAPES IN ONTARIO*

DR. LESLIE C. COLEMAN, DEPARTMENT OF BOTANY, UNIVERSITY OF TORONTO.

The Dead Arm disease of the grape vine has assumed increasing importance in Ontario within the past few years. The investigation of the disease as a co-operative project of the Provincial Horticultural Experiment Station, Vineland, and the Botany Department, University of Toronto, has been under way for about a year and a half. While much more investigation work is required, and the results obtained are by no means final, they should prove of value to the grape growers of the province.

DISTRIBUTION OF THE DISEASE.

Dead Arm is generally distributed through the grape growing area of the Niagara Peninsula. It has also been found in Kent County and is probably general in the southwestern part of the Province. Other areas have not as yet been studied but in all probability it will be found to occur in every grape growing area in the Province. It is widely distributed in the eastern United States and has been the subject of investigation by Reddick and others in New York State.†

SUSCEPTIBILITY OF DIFFERENT VARIETIES.

Field studies of this disease have been carried out during the summers of 1926 and 1927 in the Niagara Peninsula. In this time over 3000 vines have been examined with the main object of ascertaining the extent of attack and the relative susceptibility of different varieties.

Records of the disease were kept in a varietal vineyard on the Horticultural Experiment Station, Vineland, and the results which are given in Table I. indicate that there is a marked difference in susceptibility among the different varieties examined. Unfortunately the table further indicates that some of our most important commercial varieties are the most severely attacked.

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* A full report of the investigations of Dead Arm has been published in Scientific Agriculture for January, 1928.

†A general account of the disease will be found in Bulletin No. 389 (Popular Edition) of the New York (Geneva) Agricultural Experiment Station published in 1914.

TABLE I. OCCURRENCE OF DEAD ARM ON GRAPE VARIETIES. NUMBER OF SPACES IN ROW—28. AGE OF VINES—15 YEARS.

Variety.	No. of healthy vines.	No of vines showing leaf symptoms.	Total number of diseased vines.	Number of vacancies.	Percentage vines showing leaf symptoms.	Percentage vines diseased	Percentage diseased vines and total spaces.
Concord	14	11	14	0	39.2	50	50
Worden	15	10	12	1	37	44	46.4
Moore's Early	16	7	7	5	30.4	30.4	44
Campbell Early	12	6	10	6	27.2	45.4	57.2
Lindley	15	7	13	0	25	46.4	46.4
Diamond	17	6	10	1	22.2	37	39.3
Agawam	16	6	12	0	21.4	42.8	42.8
Herbert	20	5	8	0	18.5	29.6	29.6
Massasoit	24	3	4	0	10.7	14.3	14.3
Brighton	24	3	4	0	10.7	14.3	14.3
Pocklington	24	3	4	0	10.7	14.3	14.3
Wilder	25	3	3	0	10.7	10.7	10.7
Salem	16	1	12	0	3.6	42.9	42.9
Delaware	25	1	3	0	3.6	10.8	10.8
Vergennes	26	1	2	0	3.6	7.2	7.2
Niagara	27	1	1	0	3.6	3.6	3.6

The above table shows a great difference in infection in the different varieties. On the basis of both leaf symptoms and total number of vines diseased they can be divided into two groups. Concord, Worden, Moore's Early, Campbell Early, Lindley, Diamond, Agawam and Herbert show a high degree of infection. The remainder with the exception of Salem show comparatively little infection, Niagara having only one vine diseased out of the 28 in the row. Salem is peculiar in showing a high percentage of infection (12 out of 28) but only one vine with leaf symptoms. This indicates that though the variety is quite readily infected the disease makes only slow progress. On the other hand, the indications are that some of the varieties, notably Moore's Early and Campbell Early, when once attacked succumb rapidly to the disease. The five vacancies in the case of Moore's Early and the six in the case of Campbell Early are almost certainly due to death from Dead Arm.

In the above study the number of vines examined belonging to each variety was small (about 28 in each case). Probably a more accurate picture of the disease can be obtained from figures collected in commercial vineyards and these are summarised in the following table:

TABLE II. SUMMARY OF RESULTS OF INSPECTION FOR DEAD ARM IN COMMERCIAL VINEYARDS.

Vineyard.	Variety.	No of adult vines examined.	No of adult vines attacked.	No. of replacements.	No. of vacancies.	Percentage vines attacked to total adult vines.	Percentage vines attacked, replacements and vacancies to total paces.
1	Concord	583	159	173	8	27.3	44.5
2	Concord	236	41	Not recorded		17.3	
3	Agawam	623	99	0	68	15.9	24.0
4	Moore's Early	628	69	45	6	11.0	17.6
4	Niagara	88	2	0	0	2.2	
5	Niagara	462	0	0		0	

In the case of the above records of attack, all but those in the first line are based on those symptoms of leaves and arms which are recognized by growers. They do not give an accurate idea of the extent of attack as vines are usually infected two or three years before leaf and arm symptoms appear. This accounts partly for the higher figures shown for vineyard No. 1. The figures show that Concord, Agawam and Moore's Early are quite appreciably attacked while Niagara has, in the vineyards examined, shown itself almost free from the disease.

As regards the effect of the disease upon the yield we have two things to consider. In the first place we have the vacancies due to the death of vines, which may prove quite a serious matter for it is frequently rather difficult to bring on young replantings in a mature vineyard and in any case it will be several years before these vines can be brought to full bearing. In the second place, we have the gradual reduction in yield on vines that are attacked before they finally die.

Records kept in vineyards Nos. 1 and 3 during the harvest of 1927 give us some interesting yield figures. In vineyard No. 1 where records from four rows were kept, it was found that vines with pronounced leaf symptoms yielded almost exactly 12% less crop than the rest of the adult vines. If account was taken of young vines and vacancies practically all of which were the result of the disease there was a reduction of almost exactly 30% as compared with what the yield would have been had the disease not been present. In vineyard No. 3 the reduction in yield on vines showing typical symptoms was 20%, while the reduction on the total area harvested was about 10%.

These figures indicate that a reduction of crop may set in before the vines actually die and further that where the disease is bad the total loss in crop due to it can be quite serious.

Symptoms of the Disease.

The accompanying illustrations, Plates I and III and IV, give a clear idea of the typical symptoms of the disease. Plate I shows an Agawam vine photographed on the 27th June. The upper two arms show a very marked stunting of the young shoots and the leaves. Plate III, Figure A, shows a Concord vine in the last stages of the disease with growth on all the four arms stunted. A sucker is coming up from the base of the stem which shows normal foliage indicating that the root system has not been attacked. Plate IV, Figure A, shows a diseased shoot of a Campbell Early vine with a healthy one to the right for comparison. This shows clearly the stunting of the shoot and leaves, with the yellowing or chlorosis of the latter. The leaves are also malformed and curled, a typical feature of the disease. Plate IV, Figure B, shows a number of diseased leaves from a Concord vine showing chlorosis, curling and malformation. As will be noted, the yellowing occurs in the space between the veins and parts of these areas may turn brown, die, and drop out giving the leaf a shredded appearance. The stunting and malformation of leaves will enable the grower to distinguish the Dead Arm leaf symptoms from those of ordinary chlorosis or yellowing.

These leaf and arm symptoms are most distinctly visible early in the season, i.e., in June and early July. Later, secondary shoots grow out and these bear leaves which are more or less normal in color though they are usually stunted and somewhat curled. As many of the first leaves drop off and as the latter leaves do not show the typical yellowing, the disease may be easily overlooked if an

examination is made in late July or August. Plate II, shows the same vine as figured in Plate I only taken about the end of August. The leaf growth on the upper arms is still much less than on the lower ones but the chlorosis is no longer visible. It is this change which makes grape growers believe that the vines outgrow the disease during the summer. This view is, of course, quite wrong and there is no doubt whatever that next spring the upper two arms on this vine will show still more pronounced signs of the disease if they are not quite dead. Plate V. shows part of a shoot from a Moore's Early vine. The two primary leaves show the typical Dead Arm symptoms of chlorosis between the veins and curling. A secondary shoot has come out above and the leaves it bears are normal in color and shape. This shows clearly the change in leaf symptoms as the season advances.

Plate III, Figure B, shows a Moore's Early vine with the two upper arms quite dead, the buds not having burst at all. Where the disease is at all serious in a vineyard the appearance of completely dead arms is a characteristic feature.

The death of arms or vines seems to occur almost always during the winter. Out of hundreds of diseased vines examined I have seen only one with its arms dying during the early fall and that was after a prolonged period of drouth in early September, 1927.

The most important symptom of the disease is one commonly overlooked by grape growers. If the stem of a vine showing leaf symptoms is examined in the region of old stubs or other pruning wounds, after first stripping off the old bark, almost invariably a dead area or canker will be found such as is illustrated on Plate VI, Figure D. Here a large dead area extends up and down the stem from an old stub as a centre. The ridges in the stem mark the annual attempts of the vine to overgrow the diseased area. However, each year fresh stem tissue is attacked till finally the whole of it is killed in this area and the portion of the vine above the canker dies. On Plate I a very long canker can be seen on the right side of the stem extending from a short distance below the lower wire right up to the top. Plate VI, Figure C, shows a cross-section of a canker which has spread almost entirely through the stem there being a very small bit of healthy tissue left in the upper part of the section.

It is these cankers which are, in almost every case, the real seat of the disease. They may be and frequently are far removed from the portions showing leaf symptoms but they always lie in the line of conduction to those parts. It can be readily seen that, where the seat of the disease is the stem, the removal of affected arms is quite useless.

The Cause of the Disease.

The cause of the disease is a parasitic fungus (*Cryptosporella viticola*, Shear) which gains entry through pruning wounds and grows in the stem tissues consuming the materials stored up in them for use by the plant in the spring for leaf and shoot production, and killing the tissues invaded. It reproduces itself by means of spores produced in small dark colored structures which burst through the young bark. These structures (pycnidia) are shown bursting through the bark in Plate VI, Figure A. They are magnified about five times in this photograph so it will be seen that they cannot be readily made out without the aid of a magnifying glass.

During periods of moist weather the spores which are very minute elliptical structures, are pushed out through a small opening at the top of the pycnidium. They commonly stick together in a long coiled mass which readily dissolves in a drop of water (See Plate VI, Figure B). One such mass will hold many thousands of spores which can be carried in rain spray from a diseased to a healthy vine by the wind. If they fall on a wound they can germinate there and so bring about a fresh infection. Plate VII, Figures A and B show thin sections through two pycnidia magnified about 100 times. In Figure B, the spores are issuing from the top of the pycnidium. Figure C on this plate shows the centre of a pycnidium magnified about 400 times to show the spores as they are being shoved out.

These spores probably begin to emerge early in May at a time when there are a large number of comparatively fresh pruning wounds from the previous winter's pruning. The first emission seen in 1927 was on the 22nd of May but this was a late year and the observation was made at the Horticultural Experiment Station where the season is always later than it is farther from the Lake. It seems highly probable that in the period of May and early June there is the greatest danger of fresh infections.

Control Measures.

The disease is the result of wound infections on the stem or on the arm bases which lead to the formation of cankers. Infected vines can therefore be saved only if the parts above and including these cankers are removed. To locate the cankers it is necessary to strip off the old dead bark from around stubs or old wounds, on the stems of infected plants when the dead areas will become visible. Where the disease is serious in a vineyard it is necessary to examine the stems of vines which do not yet show leaf symptoms for, as already stated, the stem cankers may exist on the stems two or three years before leaf symptoms appear.

The location of diseased vines should be done in June when the leaf symptoms are most prominent. A rag should be tied around the stem just below the canker or the lowest canker where there is more than one as a mark for the pruner in the next winter. If this is not done it will be impossible to spot the vines when pruning time comes.

Where the stem canker has grown so far as to threaten to involve a further bearing portion of the vine it may be necessary to cut out at once, in which case the wound should be covered with gas tar or white lead to prevent fresh infection. At times it is necessary to stump the vine leaving a sucker to train up and in rare cases where the canker has gone down below ground level it may be necessary to remove the vine altogether. In any case the cut should show a perfectly healthy surface with no dark area, otherwise the disease will keep on spreading and involve the new growth.

To prevent spore infection of the pruning wounds in May and June a spray with Bordeaux in early May before the leaves come out is recommended. This should be directed on to the pruning wounds especially the larger ones as there is some evidence that these are the ones most readily infected. A second spray about the end of May or the beginning of June might also be advisable.

Plate I. Grape vine, Agawam variety, showing typical Dead Arm symptoms on the two upper arms and a long diseased area on the stem. Photo 27th June, 1927.

Plate II. The same vine as shown on Plate I. The secondary branches and leaves have developed, masking the symptoms. Photo end of August, 1927.

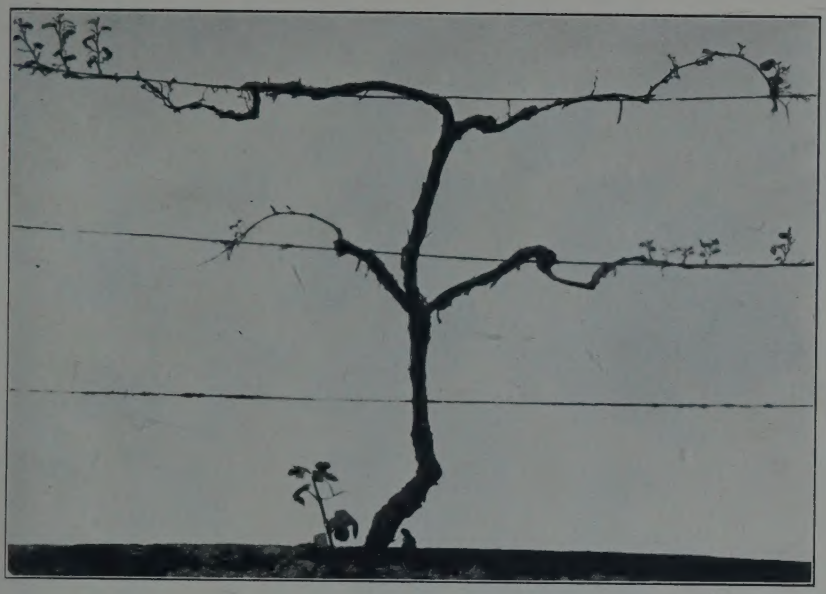

Figure A

Figure B

Plate III. Figure A. Grape vine, Concord variety, in advanced stage of Dead Arm, showing healthy sucker coming up from base of stem. Photo 24th June, 1927. Figure B. Grape vine, Moore's Early variety showing the two upper arms dead. Diseased area extends to top from point where knife is stuck into stem. Photo 5th July, 1927.

Figure A

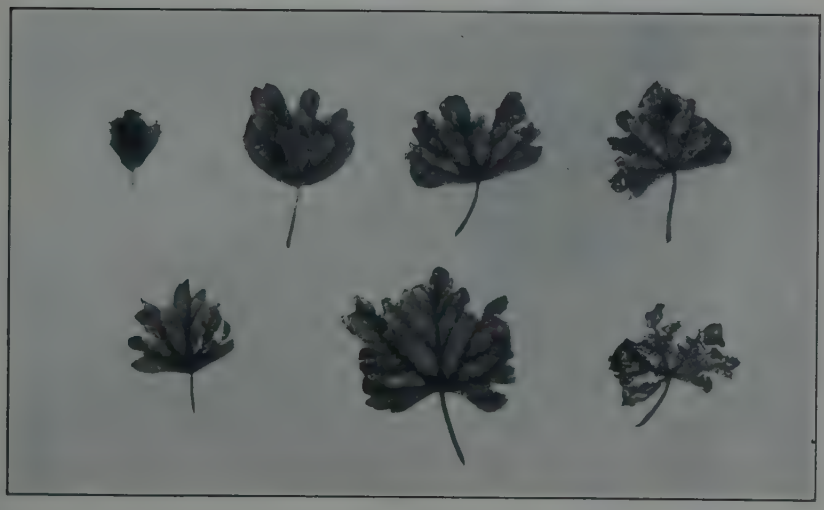

Figure B

Plate IV. Figure A. Diseased and healthy branches of grape vine, Campbell Early variety, to show typical leaf and branch symptoms. Photo 30th June, 1927. Figure B. Leaves from a diseased branch of grape vine, Concord variety, to show chlorosis, curling, malformation, and shredding typical of disease. Photo 13th July, 1927.

Plate V. Portion of a diseased branch from a vine, Moore's Early variety. Two primary leaves showing typical symptoms are present. From the axil of the upper one has developed a branch bearing leaves of a normal colour and shape. Photo 11th July, 1927.

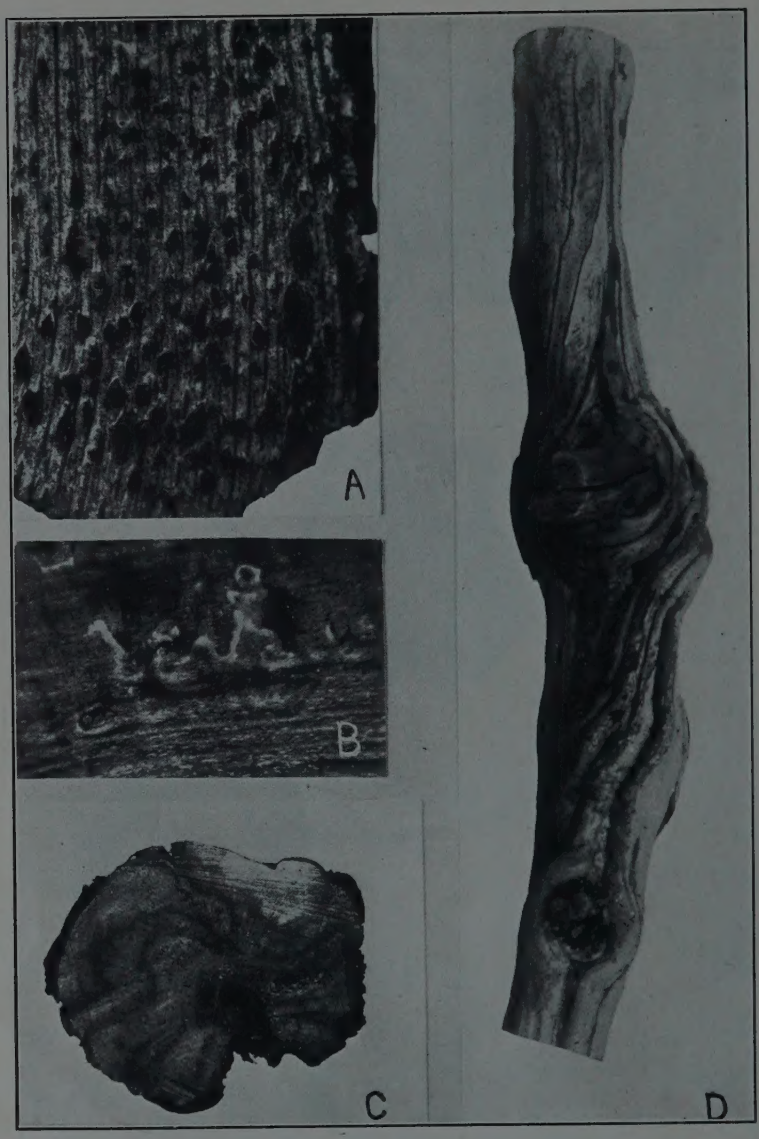

Plate VI. Figure A. Bark from near margin of diseased area on a grape arm, Niagara variety, to show pycnidia of '*Cryptosporella viticola*,' Shear, breaking through. Magnification about 5 diameters. Photo 16th July, 1927. Figure B. Small area on bark of stem lesion showing emission of spores in twisted threads. Photo July, 1926. Figure C. Cross-section of a grape stem, Concord variety, taken through an old diseased area to show annual progress of disease and development of secondary rot. Slightly reduced. Photo February, 1927. Figure D. Piece of grape stem, Concord variety, showing typical diseased area about an old stub. Photo February, 1927.

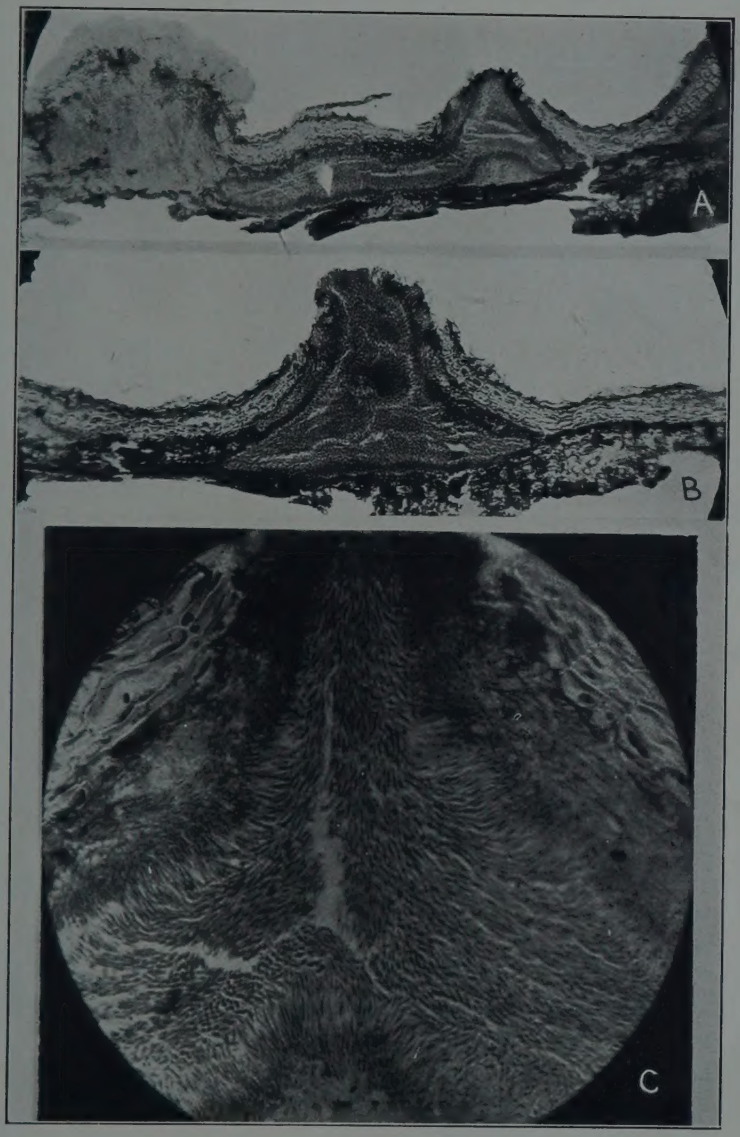

Plate VII. Figure A. Longitudinal section of bark of grape stem, Niagara variety, showing to the right a pycnidium with an extended base breaking through cork layer and to the left a sterile mycelial mass which has broken through. Figure B. Similar section showing pycnidium emitting spores. Most of the emitted mass has been washed away in the preparation. Figure C. Centre of a pycnidium from same material showing attachment of conidiospores and spores being forced towards the opening.